Journal of Forensic and Legal Medicine 16 (2009) 385–387

Contents lists available at ScienceDirect

Journal of Forensic and Legal Medicine

journal homepage: www.elsevier.com/jflm

Original Communication

Carbon monoxide poisoning in Morocco during 1999–2007

M. Ait El Cadi *, Y. Khabbal, L. Idrissi

Laboratory of Forensic Toxicology, National Institute of Health Morocco, 27, Avenue Ibn Batouta, BP 769 Rabat, Morocco

ARTICLE INFO

Article history:
Received 4 May 2008
Received in revised form 2 June 2008
Accepted 15 January 2009
Available online 3 April 2009

Keywords:
Carbon monoxide (CO)
Forensic toxicology
Acute poisoning
Inhalation

ABSTRACT

Introduction: Carbon monoxide (CO) intoxication is one of the most common types of poisoning in the modern world. The aim of the present study is to describe the evolution of CO poisoning during a period between January 1999 and December 2007 based on data collected from result of toxicological analysis in the laboratory of toxicology in the National Institute of Health in Morocco.

Materials and methods: This study was based on autopsies samples sent to the laboratory of forensic toxicology covering the time period January 1999 to December 2007. Cases were analyzed according to the following criteria: age, region, month, gender, presence or not of autopsy report and post mortem blood carbon monoxide determination.

Result: From January 1999 to December 2007, 139 out of the 4402 analysis performed were recorded as acute CO intoxications. Cases (93.5%) were classified as accident (E859). Hundred percentage of our cases were exclusively due to gaze inhalation. Circumstances of intoxications were described in autopsy report which is found in 41% (57 cases). Males predominated in accidental poisoning with 77 cases (55%) while females represented 62 cases (44%). the most represented city was Rabat with 48 cases (34%), followed by Casablanca with 20 cases (14.4%). the highest frequency of CO deaths was found in February and March with 29 cases (20.9%) and 28 cases (20.1%), respectively. The highest poisoning frequency was recorded for the age mean 34± years old. The average of carbon monoxide concentration was 5.76 ± 4.3 ml/100 ml of blood. Males predominated in accidental poisoning with 77 cases (55%) while females represented 62 cases (44%).

Conclusion: Acute carbon monoxide intoxication is too dangerous because of its speed in addition to the particularities of carbon monoxide which is one of many ubiquitous contaminants of our environment that requires prevention and control measures inside and outside to insure adequate protection of public health.

Published by Elsevier Ltd.

1. Introduction

Carbon monoxide (CO) is a colorless, odorless, and poisonous to humans gas.[1] Exposure to carbon monoxide can be detrimental to human health, and exposure to higher concentrations can result in death. Exposure to carbon monoxide can be either intentional or accidental. Carbon monoxide intoxication is one of the most common types of poisoning in the modern world, developed and developing countries alike.[2,3] The true incidence of CO poisoning is unknown and many cases probably go unrecognized.[4] CO intoxication remains an important cause of morbidity and mortality in industrialized countries. Mortality in USA was 8.8 deaths per million person in 1998,[5] and in France, the average incidence of CO intoxication is 17.5 per million.[6] The two most common sources of the gas in acute poisoning are smoke from fires and car engine exhaust fumes. Other sources include the use of charcoal grille in confined spaces. However, it is worth stating here that low concentrations (20–120 ppb) are considered a normal constituent of the natural environment. There are also endogenous sources of carbon monoxide, such as during the heme degradation to bile pigments. CO produced endogenously serves as a signaling molecule involved in multiple cellular functions, such as inflammation, proliferation and apoptosis. Carbon monoxide was recently defined as a gaseous neurotransmitter in the central nervous system.[4]

The aim of the present study is to describe the CO poisoning during a period between January 1999 and December 2007 from result of toxicological analysis in the Laboratory of Toxicology in the National Institute of Health in Morocco.

2. Materials and methods

In Morocco, the department of Forensic Toxicology in the National Institute of Health investigates unnatural deaths. Toxicological analyses are centralized in this laboratory which receives samples from different Institutes of Forensic Medicine in Morocco. Blood and samples are usually screened for medical drugs and ethanol. Carbon monoxide is only searched when the pathologist suspect the existence of poisoning.

* Corresponding author. Tel.: +212 66 08 91 08/37 77 19 02/37 77 19 65; fax: +212 37 77 20 67/68 16 53.
E-mail address: macadiph@yahoo.fr (M. Ait El Cadi).

1752-928X/$ - see front matter Published by Elsevier Ltd.
doi:10.1016/j.jflm.2009.01.017

Table 1
Number of fatal deaths due to CO poisoning (1999–2007).

Years	Number of autopsies	Frequency of CO poisoning	Percentage of CO poisoning (%)
1999	439	19	13.66
2000	470	4	2.87
2001	360	4	2.84
2002	689	12	8.63
2003	625	17	12.23
2004	403	23	16.55
2005	557	31	22.39
2006	554	20	14.38
2007	305	9	6.47
Total	4402	139	

This study was based on autopsies samples sent to the laboratory of forensic toxicology covering the time period lasting from January 1999 to December 2007.

Cases were selected from the forensic toxicology and forensic pathology database including all autopsies where report mentioned CO intoxication. CO's value of 2.8 ml/100 ml of blood is considered as positive. Cases were analyzed according to the following criteria: age, region, month, gender, presence or not of autopsy report and post mortem blood carbon monoxide determination. Additional information regarding circumstances of death were mentioned by the police or by the pathologist.

Submitted blood samples were analyzed for CO by micro diffusion in Conway cell associated to volumetric assai.[7,8] The recorded poisonings were classified according to the international classification of diseases (ICD-10) to voluntaries, accidental and undetermined intoxications.[9]

3. Results

From January 1999 to December 2007, 139 out of the 4402 analyses performed were recorded as acute CO intoxications. Hundred and thirty cases (93.5%) were classified as accident (E859) and 9 cases (4.35%) were classified as uncertain. Hundred percentage of our cases were exclusively due to gas inhalation. Circumstances of intoxications were described in autopsy report which is found in 41% (57 cases). The total number of autopsies per year has not changed considerably, the average of autopsies that the laboratory received each year was (880 ± 42) with a maximum value in 2002 and a minim value in 2007 (Table 1). Carbon monoxide poisoning had a minimum value (4 cases) both in the year 2000 and 2001 and a maximum value (31 cases) in 2005.

Samples came from the majority of Moroccan cities. However the most represented city was Rabat with 48 cases (34%), followed by Casablanca with 20 cases (14.4%) and then Meknes (13.7%) and kenitra (11.5%) (Fig. 1). This repartition can be explained by the fact that CO poisoning were not reported by all regions of Morocco especially rural regions which do not have forensic institutes. Males predominated in accidental poisoning with 77 cases (55%) while females represented 62 cases (44%).

According to Fig. 2 we can conclude that the highest frequency of CO deaths was found in February and March with 29 cases (20.9%) and 28 cases (20.1%), respectively.

The highest poisoning frequency was recorded for the age mean of 34± years. The average of carbon monoxide concentration was 5, 76 ± 4.3 ml/100 ml of blood. The incidence of mortality of CO poisoning in this period was 0.142 per 100,000 populations.

4. Discussion

During the period between 1999 and 2007, 139 cases (3.15%) of carbon monoxide poisoning death were reported, this percentage may be not significant because of the lack of declarations in many regions especially the rural ones. Some papers confirmed our result in many other countries despite variations in these countries.[10,11] CO death evolution in time showed an increase from 1999 to 2005, and then it went on decreasing. This evolution could be explained by the better treatment of those intoxications in hospitals, and the opening of new forensic laboratories which could explain the decrease of samples that our laboratory receives.

Almost all the cities were represented but the axis Rabat–Casablanca is still the most affected by this intoxication, respectively, with 34.5% and 14.4% followed by Meknes and Kenitra. We can also note unsteadiness in the repartition of CO death. This is difficult to explain but it may due to lack of information in small cities which do not have forensic institutes.

Carbon monoxide death is exclusively accidental by inhalation. This is not surprising; it confirms literature data.[12] CO poisoning is important in cool period of year (December, January and February), it results from unintentional exposure to inhalations in confined

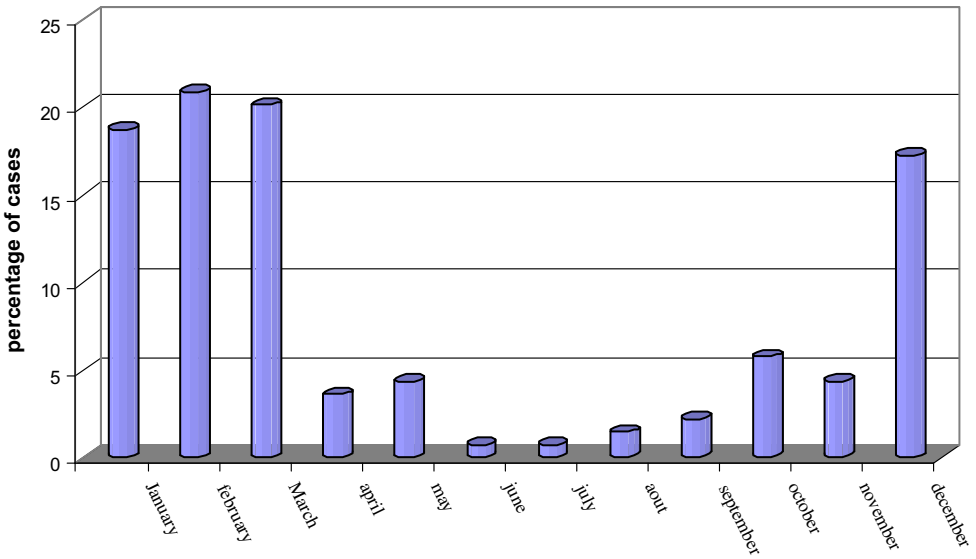

Fig. 1. CO poisoning death as recorded for cities during the period 1999–2007.

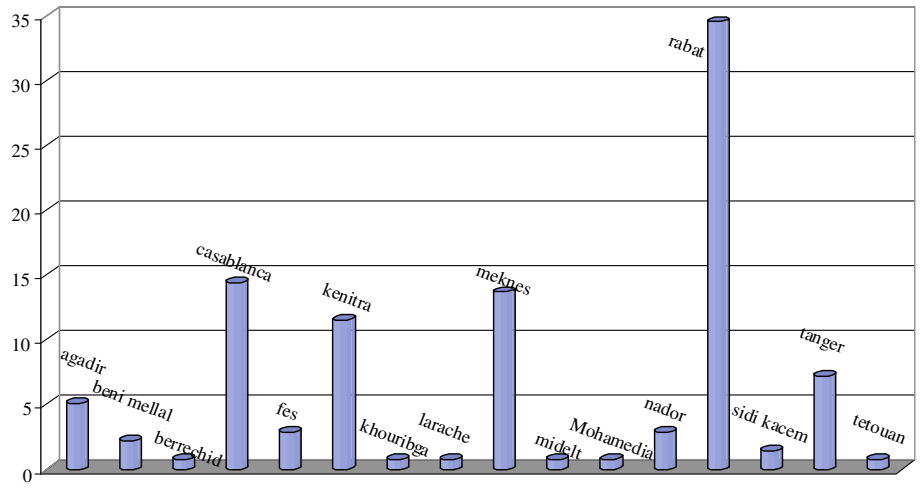

Fig. 2. CO poisoning death as recorded for months during the period between 1999 and 2007.

spaces when a heating unit is used only occasionally and not well maintained. It is known that Epidemics of CO poisoning are more common during the winter months, particularly when power outages occur forcing people to use traditional wood-burning as a source of heat.[13,6]

There are many sources of exposure to CO in acute and chronic ways. Tobacco smoke contains CO; heavy cigarette smokers may have levels of 10% wile cigar smokers can achieve up to 20% COHb. In our study we did not take smoking into consideration in our interpretation of CO level because we did not have any information about it in autopsy report. The internal combustion engine accounts for approximately 60% of the CO produced and severe traffic congestion in urban streets can produce sufficient CO to provoke symptoms of toxicity. Concentrations of CO can be high in tunnels and parking garages due to the accumulation of motor exhaust fumes. Poorly vented water-heaters, fireplaces, space heaters and furnaces are all sources in our own homes,[14] which makes us wonder if there is no link between those different ways of exposure to carbon monoxide and the increase of poisoning and deaths especially in the biggest cities in Morocco such Rabat and Casablanca.

The average of CO concentration found in our series was 5.76% (57600 ppm). This percentage is too high and it is responsible of death in all cases according to (*Jain*)[15] who mentioned that respiratory and cardiac arrest happen with a concentration of CO equal or more than 2000 ppm. It is important to signal that this concentration could be underestimated because of the time elapsed between deaths, autopsies and analysis. It is known that CO level decrease quickly after death.[16]

5. Conclusion

Carbon monoxide poisoning is one of the most important intoxications in the world including Morocco. Acute intoxication is too dangerous because of its speed in addition to the particularities of carbon monoxide (CO) which is one of many ubiquitous contaminants of our environment that requires prevention and control measures indoors and outdoors to insure adequate protection of public health. Outdoors, focus of air pollution control by industrialized societies has been the regulation of CO in ambient air and occupational settings. To control CO exposure indoors, we should control heating unit and all source of combustion. Some communities now require the installation of CO detectors in residences, along with smoke detectors and fire alarms but further studies are needed to follow the evolution of those investigations.

Conflicts of Interest

None declared.

Funding

None declared.

Ethical Approval

None declared.

References

1. Antioco FS, Rossi G. Death scene evaluation in a case of fatal accidental carbon monoxide toxicity. *Forensic Sci Int* 2006;**164**:164–7.
2. Kelechi N, Iheagwara A, Stephen R, et al. Myocardial cytochrome oxidase activity is decreased following carbon monoxide exposure. *Biochim Biophys Acta* 2007;**1772**:1112–6.
3. Gorman D, Drewry A, Huang YL, Sames C. The clinical toxicology of carbon monoxide. *Toxicology* 2003;**187**:25–38.
4. Leon DP, Rossitza IC. Carbon monoxide intoxication: an updated review. *J Neurol Sci* 2007;**262**:122–30.
5. Mott J A, Wolf M I, Alverson CJ, et al. National vehicle emission policies practices and declining US carbon monoxide-related mortality. *JAMA* 2002;**288**:988–95.
6. Marc B, Bouchez-Buvry A, Weipierre J-L, Boniol L, Vaquero P, Garnier M. Carbon-monoxide poisoning in young drug addicts due to indoor use of a gasoline generator. *J Clin Forensic Med* 2001;**8**:54–6.
7. Frejaville JP, christophorov B, Bismuth C, Peyroula FP. Toxicologie clinique et analyique. 2ème èdition Flammarion Médecinee-science; 1975.
8. Malbosc R. Intoxications aigue et chronique par le monoxyde de carbone: aspect analytique et interprétation des oxycarbonémies. *Revue française des laboratoires* 2000;**323**:19–25.
9. Jonsson A, Holmgren P, Ahlner J. Fatal intoxications in a Swedish forensic autopsy material during 1922–2002. *Forensic Sci Int* 2004;**143**:53–9.
10. Chaturvedi AK, Dudley RS, Dennis VC. Blood carbon monoxide and hydrogen cyanide concentrations in the fatalities of fire and non fire associated civil aviation accidents, 1991–1998. *Forensic Sci Int* 2001;**121**:183–8.
11. Neil B, Hampson MD. Trends in the incidence of carbon monoxide poisoning in the united state. *Am J Emerg Med* 2005;**23**:838–41.
12. Theodore Vougiouklakis MD, Vassiliki AB, Antigony M. Fatal poisoning in the region of Epirus, Greece, during the period 1998–2004. *J Clin Forensic Med* 2006;**13**:321–5.
13. Omaye ST. Metabolic modulation of carbon monoxide toxicity. *Toxicology* 2002;**180**:139–50.
14. Raub JA, Nolf MM, Hampson NB, Stephen R. Thom Carbon monoxide poisoning – a public health perspective. *Toxicology* 2000;**145**:1–14.
15. Jain KK. Carbon monoxide and other tissue poisons. Textbook of hyperbaric medicine. Hogrefe and Huber Inc. p. 141–1 chapter 12.
16. Harvey WR, Hutton P. Carbon monoxide: chemistry, role, toxicity and treatment. *Curr Anaesth Crit Care* 1999;**10**:158–63.